

De relatie tussen luisterinspanning en werkgeheugen

T. Koelewijn, A.A. Zekveld, K. Mortier, J.M. Festen, & S.E Kramer

Afd. KNO/Audiologie, EMGO+ Instituut, VU medisch centrum, Amsterdam

Cognitieve inspanning

Vis Kat Hond Paard...

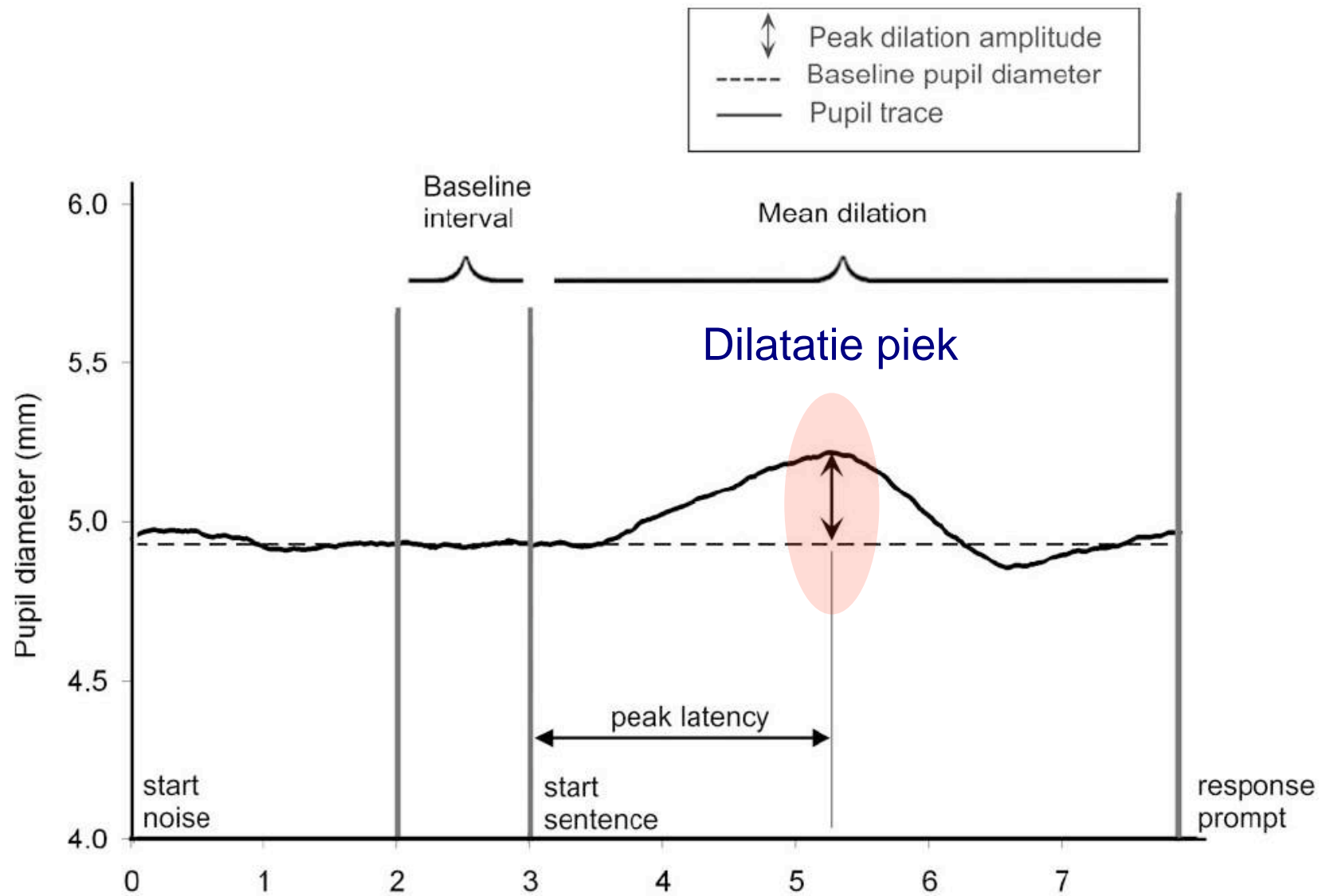


24 + 12 + 6 + 3 ...



Luisterinspanning





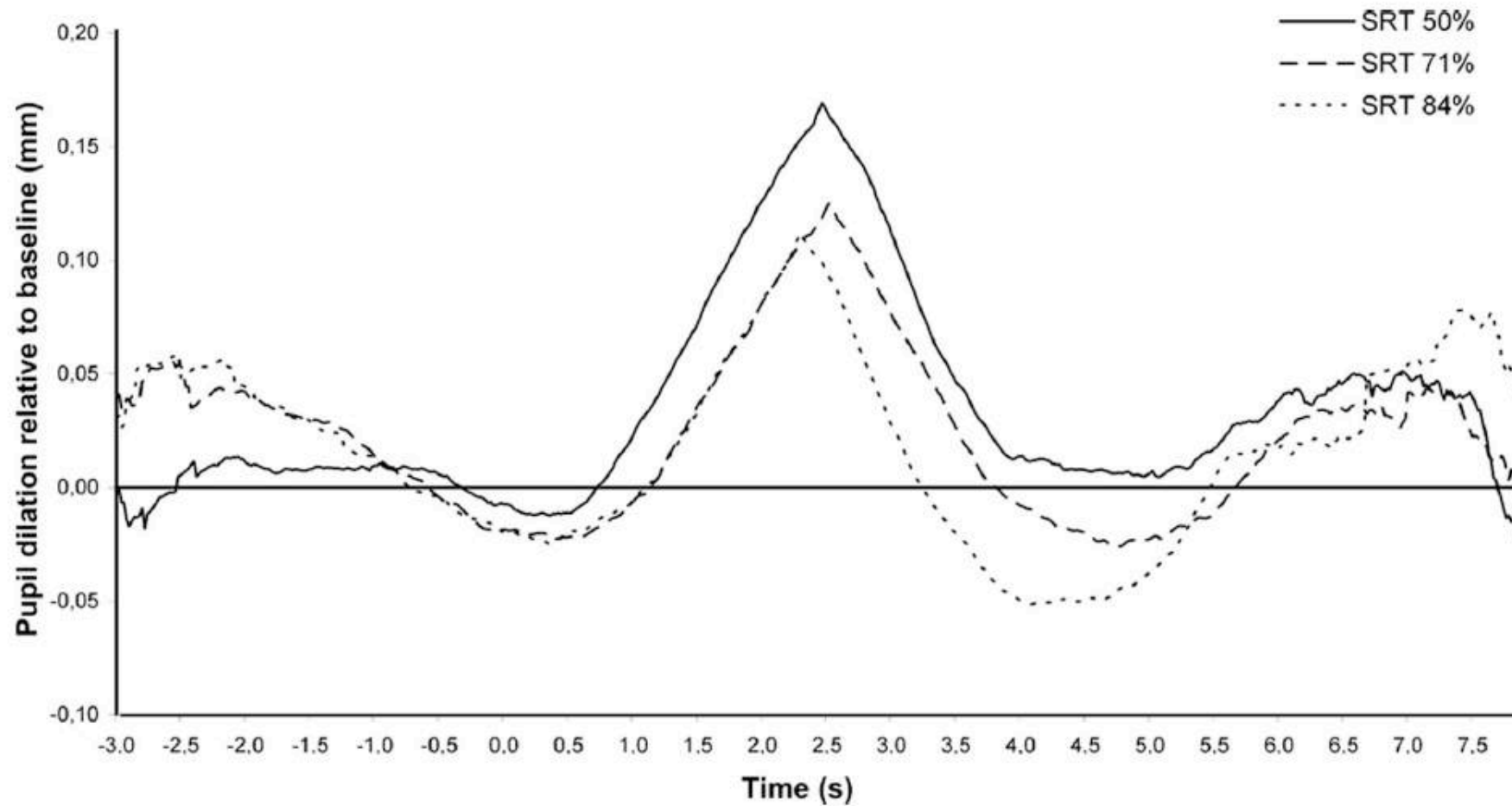
Overzicht

- Speech Reception Threshold (SRT) tests (Plomp & Mimpen 1979) in combinatie met pupillometry (Kramer et al. 1997)
- Studie 1: Verstaanbaarheid (Zekveld et al. 2010, 2011)
- Studie 2: Absoluut geluidsniveau (Mortier et al. under review)
- Studie 3: Type maskeerder (Koelewijn et al. 2012)
- Studie 4: Werkgeheugen (Koelewijn et al. in prep)

Studie 1: Verstaanbaarheid

- Deelnemers:
 - 38 normaal horende studenten (leeftijd 19-31 jaar, gemiddeld 23 jaar)
- SRT:
 - Aanbiedingsniveau stond vast op 55 dB(A) SPL
 - Verstaanbaarheid (adaptieve procedure)
 - 50% correct (1-up-1-down)
 - 71% correct (2-up-1-down)
 - 84% correct (4-up-1-down)

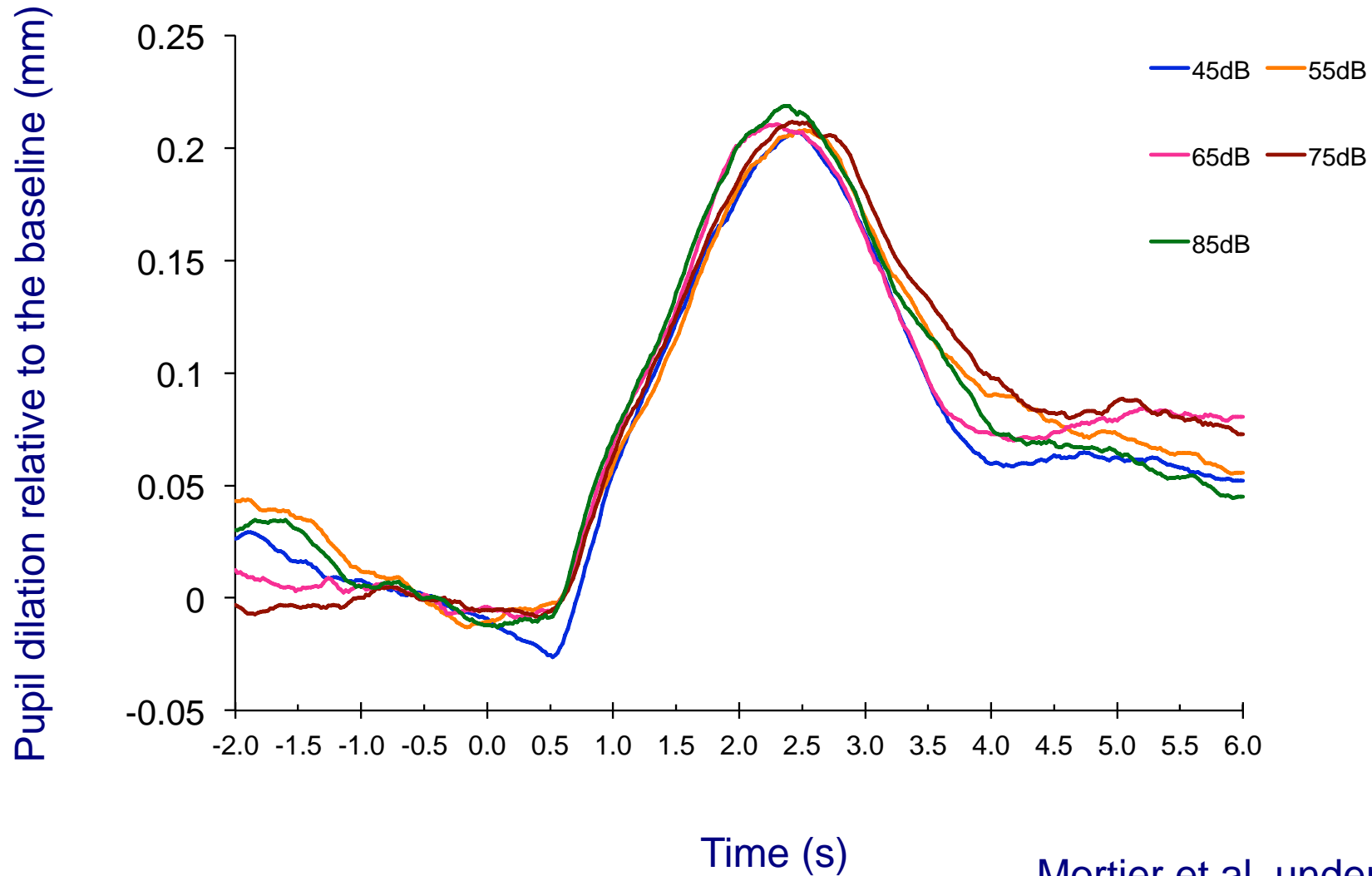
De pupil response is significant groter bij 50%
verstaanbaarheid dan bij 71% of 84%



Studie 2: Absoluut geluidsniveau

- Deelnemers: 20 normaal horende studenten (leeftijd 18-35 jaar, gemiddeld 24 jaar)
- SRT:
 - Verstaanbaarheid 50%
 - Het ruisniveau stond vast
45, 55, 65, 75, and 85 dB(A) SPL

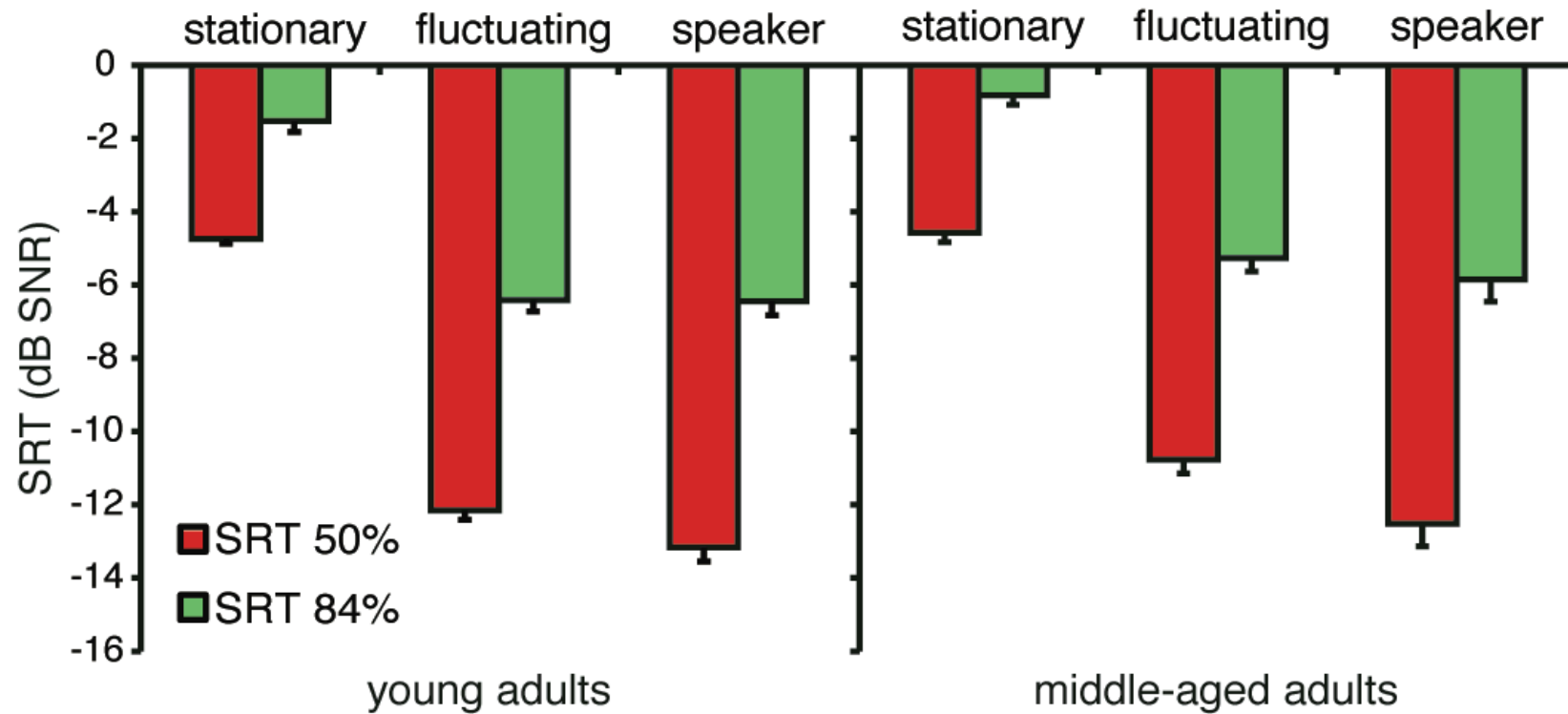
Verstaanbaarheid vast op 50%
 Dilatatie verschilt niet tussen luidheidsniveaus



Studie 3: Type maskeerder

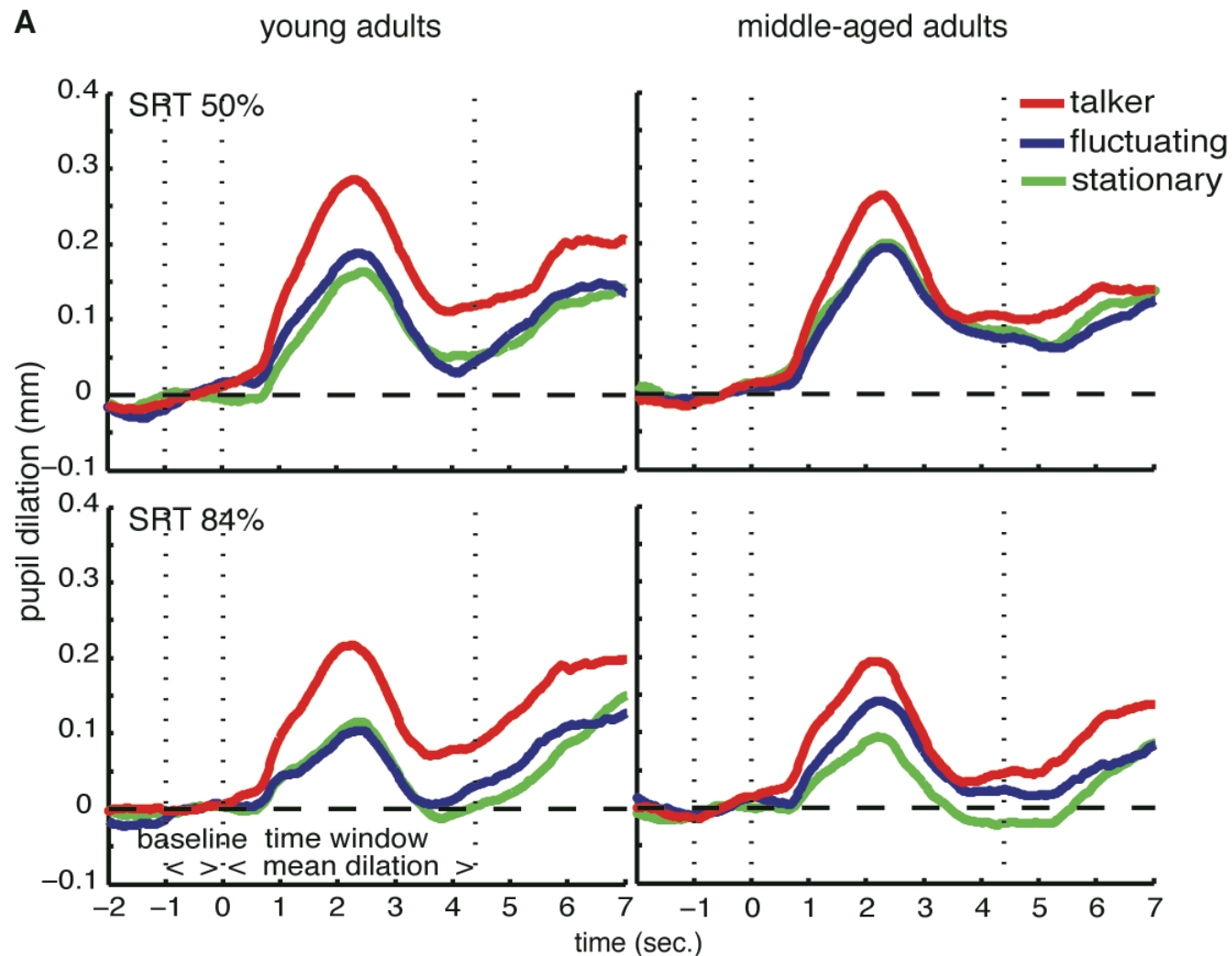
- Deelnemers:
 - 24 normaal horende jong volwassenen (leeftijd 18-31 jaar, gemiddeld 22 jaar)
 - 24 normaal horende volwassenen (leeftijd 47-63 jaar, gemiddeld 56 jaar)
- SRT
 - Verstaanbaarheid op 50% en 84%
 - Spraakniveau lag vast op 55 dB(A) SPL
 - Type Maskeerder
 - stationary noise
 - fluctuating noise
 - Speaker

SRTs 50% < SRTs 84%
 SRTs stat > SRTs fluc > SRTs speaker




Normaal horenden

SRTs 50% > SRTs 84%
 SRTs stat = SRTs fluc < SRTs speaker



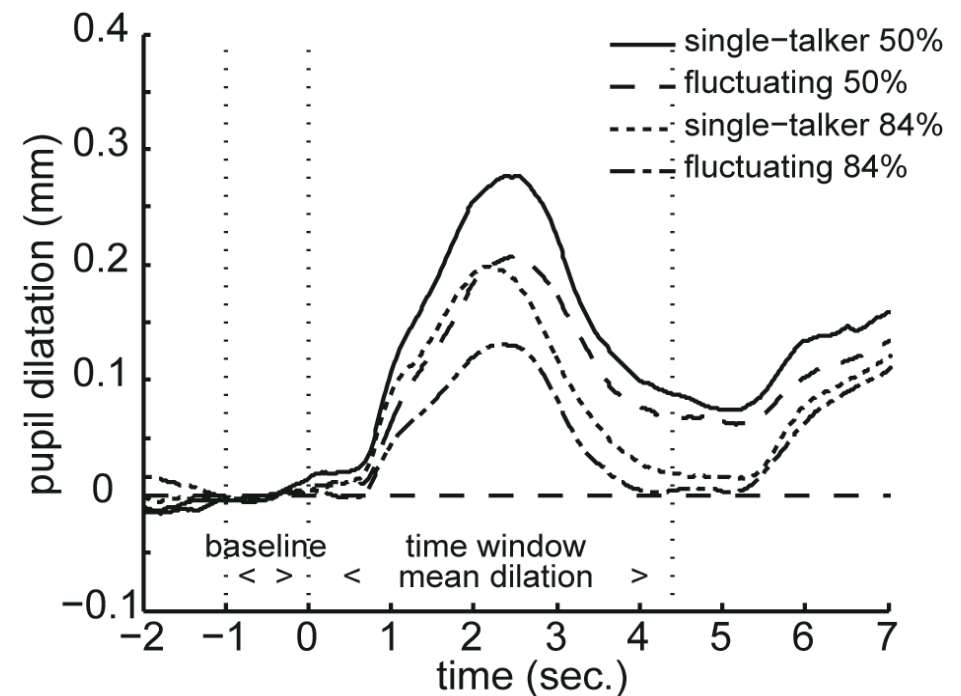
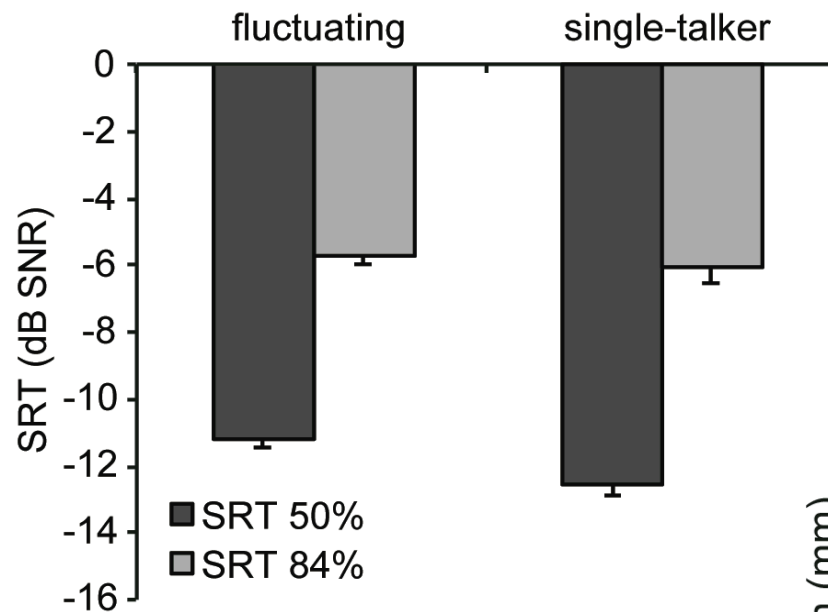
Studie 4: Werkgeheugen

- Deelnemers:
 - 32 normaalhorende volwassenen (leeftijd 40-70 jaar, gemiddeld 51 jaar)
- SRT
 - Verstaanbaarheid: 50%, 84%
 - Maskeerders: fluctuating noise, speaker
- Cognitieve taken
 - Werkgeheugen: Rspan, Lspan, SICspan
 - TRT 

Studie 4: Onderzoeksvraag

- Cognitieve vaardigheden hebben invloed op spraak verstaan (Akeroyd 2008, Lunner et al. 2007, Rönnberg 2003, Zekveld et al. 2011)
- Wordt de luisterinspanning (pupil response) ook beïnvloed door cognitie?

Resultaten van studie 3 gerepliceerd



Studie 4: Resultaten

- SRT
 - Scores op de SRT worden deels verklaard door cognitieve capaciteit (SICspan, TRT) en leeftijd.
 - Hoe groter onze capaciteit hoe beter de SRT scores
- Pupil
 - Pupil dilatatie wordt, alleen in de moeilijkste condities, deels verklaard door de SICspan en TRT
 - Hoe groter onze capaciteit hoe groter de piek dilatatie

Conclusies

- Pupil dilatatie is gevoelig voor verstaanbaarheid van spraak
- Pupil dilatatie is niet gevoelig voor het absolute aanbiedingsniveau
- Het verstaan van spraak in interfererende spraak kost meer inspanning dan in fluctuerende ruis
- Hoe groter onze cognitieve capaciteit (bv. werkgeheugen) hoe beter we spraak verstaan, maar hoe meer inspanning we leveren
- De pupil geeft aanvullende informatie ten opzichte van de SRT

For more information, see:

Kramer et al. (1997) *Audiology* 36, 155-164

Zekveld et al. (2010) *Ear and Hearing* 31, 480-490

Zekveld et al. (2011) *Ear and Hearing* 32, 498-510

Koelewijn et al. (2012) *Ear and Hearing*

Epub ahead of print

.....and future publications.....

or: t.koelewijn@vumc.nl

Original Article

Audiology 1997; 36:155-164

Sophia E. Kramer
Theo S. Kapteyn
Joost M. Festen
Dirk J. Kuik

Clinical Audiology
Department of Otolaryngology
University Hospital VU
Amsterdam, The Netherlands

Assessing Aspects of Auditory Handicap by Means of Pupil Dilatation

Pupil Response as an Indication of Effortful Listening: The Influence of Sentence Intelligibility

Adriana A. Zekveld, Sophia E. Kramer, and Joost M. Festen

Objective: The aim of this study was to evaluate the influence of sentence intelligibility on the pupil dilation response during listening. Task-related pupil dilation reflects auditory processing load. Therefore, pupil dilation can be used to examine the listening effort during speech perception in difficult listening conditions. We expected to find increasing pupil dilation as a function of decreasing sentence intelligibility.

Design: Thirty-eight young participants (mean age = 25.5 years) with normal hearing were recruited. They received threshold (SRT) tests in which the stationary noise. A six-up six-down, 70-dB condition adaptive procedure was applied, followed by 50, 71, or 84% of the sentence (SRT₅₀, SRT₇₁, or SRT₈₄), respectively. We examined the pupil dilation of the pupil dilation response, and during the processing of the speech in each peak dilation amplitude and mean pupil dilation to the baseline and standard deviation (SD) SRT condition, participants rated the separate estimated their performance level.

Results: The signal to noise ratio (SNR) in SRT₅₀ conditions increased as a function of load. The subjective effort ratings decreased as sentence intelligibility increased. Pupil dilation measures increased with increasing load. Overall measures analysis of variance indicated that mean pupil dilation was higher in conditions with SRT₅₀ and SRT₇₁ compared with SRT₈₄ conditions. Mean pupil dilation and peak dilation SD increased with increasing load. Pupil dilation measures were assessed across conditions and higher for the most difficult conditions. The amplitude of the effect on the peak dilation amplitude of the pupil response was higher in the SRT₅₀ and SRT₇₁ conditions. Within the first and third load, the mean pupil dilation decreased as a function of the load. Spearman correlation analyses among SRTs, the SRTs, subjective effort ratings, and pupil dilation measures.

Conclusions: The pupil dilation amplitude was higher in conditions with decreasing sentence intelligibility. These results suggest that listening effort, as measured by increasing subjective effort ratings, can be used to assess a certain performance level. Application of listening effort can yield reliable hearing and cognitive function hearing conditions and the individual differences in speech perception. (*Ear & Hearing* 2001;32:155-164)

Department of ENT/Audiology and the Eindhoven University of Technology, Eindhoven, The Netherlands; VU University Medical Center, Amsterdam, The Netherlands

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

INTRODUCTION

When speech understanding is impaired by background noise or hearing loss, speech comprehension becomes more reliant on cognitive (top-down) working memory processes to fill in missing information (Zekveld et al., 2010).

Cognitive Load During Speech Perception in Noise: The Influence of Age, Hearing Loss, and Cognition on the Pupil Response

Adriana A. Zekveld, Sophia E. Kramer, and Joost M. Festen

Objective: The aim of the current study was to evaluate the influence of age, hearing loss, and cognitive ability on the cognitive processing load during listening to speech presented in noise. Cognitive load was assessed by means of pupal dilation (i.e., pupil dilation) accompanied with subjective ratings.

Design: Two groups of sixteen participants (mean age = 25.5 years) with normal hearing and sixteen participants (mean age = 65.5 years) with hearing loss (mean hearing threshold (HT) in stationary noise) were recruited. They received a speech-to-noise ratio (SNR) required for 50%, 71%, or 84% of the sentence (SRT₅₀, SRT₇₁, or SRT₈₄), respectively. We examined the pupil dilation response, the peak latency, the mean dilation amplitude, and the SD of the pupil dilation response for each condition. Participants were also asked to estimate their performance level. Pupil dilation measures were assessed across conditions and higher for the most difficult conditions. The amplitude of the effect on the peak dilation amplitude of the pupil response was higher in the SRT₅₀ and SRT₇₁ conditions. Within the first and third load, the mean pupil dilation decreased as a function of the load. Spearman correlation analyses among SRTs, the SRTs, subjective effort ratings, and pupil dilation measures.

Conclusions: The pupil dilation amplitude was higher in conditions with decreasing sentence intelligibility. These results suggest that listening effort, as measured by increasing subjective effort ratings, can be used to assess a certain performance level. Application of listening effort can yield reliable hearing and cognitive function hearing conditions and the individual differences in speech perception. (*Ear & Hearing* 2010;31:480-490)

Department of ENT/Audiology and the Eindhoven University of Technology, Eindhoven, The Netherlands; VU University Medical Center, Amsterdam, The Netherlands

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

01964820/11/0305-0010-0

INTRODUCTION

When speech comprehension is difficult due to hearing loss or background noise, the reliance on cognitive processes to fill in missing information (Zekveld et al., 2010).

Pupil Dilation Uncovers Extra Listening Effort in the Presence of a Single-Talker Masker

Thomas Koelewijn,¹ Adriana A. Zekveld,^{1,2,3} Joost M. Festen,¹ and Sophia E. Kramer¹

Objective: Recent research has demonstrated that pupil dilation, a measure of mental effort (cognitive processing load), is sensitive to differences in speech intelligibility. The present study extends this outcome by examining the effects of masker type and age on the speech reception threshold (SRT) and mental effort.

Design: In young and middle-aged adults, pupil dilation was measured while they performed an SRT task, in which spoken sentences were presented in stationary noise, fluctuating noise, or together with a single-talker masker. The masker levels were adjusted to achieve 50%, or 84% sentence intelligibility.

Results: The results show better SRTs for fluctuating noise and a single-talker masker compared with stationary noise, which indicates results of previous studies. The peak pupil dilation, reflecting mental effort, was larger in the single-talker masker condition compared with the other masker conditions. Paradoxically, in contrast to the thresholds, no differences in peak dilation were observed between fluctuating noise and stationary noise. This effect was independent of the intelligibility level and age.

Conclusions: To maintain similar intelligibility levels, participants needed more mental effort for speech perception in the presence of a single-talker masker than with the two other types of maskers. This suggests an additive masking effect of speech information from the single-talker masker. The dissociation between these performance and mental effort measures underlines the importance of including measurements of pupil dilation as an independent index of mental effort during speech processing in different types of noisy environments and at different intelligibility levels. (*Ear & Hearing* 2012;33:155-164)

INTRODUCTION

Following a conversation in a noisy environment such as a construction site or an office canteen can be a difficult and tiring task. The louder the background noise, the more we need to concentrate and make an effort to understand the message. There is a range of studies suggesting that higher cognitive processes such as working memory and attention are involved in such a speech intelligibility task (Festen & Plopp 2002; Rönberg et al. 2008; Kramer et al. 2009). According to these studies, cognitive processes are required to filter out disturbing information and/or fill in the missing information. The less intelligible the speech becomes, the more listeners need to use these cognitive mechanisms (Festen & Nabelek 2009) to comprehend the message. It is often assumed that this cognitive load may contribute to the experienced mental effort during listening in adverse conditions (Rabbitt 1968; Wingfield et al. 2005; Zekveld et al. 2010, 2011).

¹Department of ENT/Audiology and IMAGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands; ²Amsterdam Center HEAD, The Swedish Institute for Disability Research, Linköping University, and ³Department of Behavioral Science and Learning, Linköping University, Linköping, Sweden.

Bedankt voor uw aandacht!

Pupillometry research-group at VUmc Amsterdam



Sophia Kramer



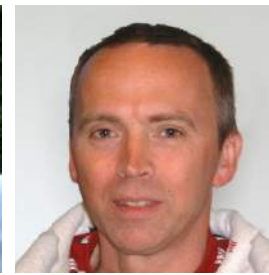
Adriana Zekveld



Thomas Koelewijn



Karen Mortier



Hans van Beek



Joost Festen